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Supporting Information for

Evaluating Drought Responses of Surface Ozone Precursor Proxies: Variations with Land Cover Type, Precipitation, and Temperature

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Introduction

Supporting Information for "Evaluating Drought Responses of Surface Ozone Precursor Proxies: Variations with Land Cover Type, Precipitation, and Temperature" includes supporting texts, figures, and tables to the main text. The data used and presented in Supporting Information can be found in the data repository described in the Acknowledgements section of the main text.

Text S1

Of the 17 land cover types classified by the International Geosphere-Biosphere Program, 15 are present in the Eastern US (Figure S1; also see Table 1 in Strahler et al., 1999). Of those 15 land cover types, we include in our sub-regional analyses only those that make up at least 3% of the Eastern US area, while also excluding "Water Bodies" from analysis because of their isolation from both human populations and drought index measurements (Figure S1; Table S1). Additionally, we exclude "Savannas" from sub-regional analyses, even though they comprise more than 3% of the Eastern US, because of their staggered spatial distribution (Figure S1). Therefore, we restrict sub-regional analyses in the Eastern US to croplands, grasslands, woody savannas, deciduous broadleaf forests, and mixed forests (Table S1).

Text S2

While OMI/Aura offers the potential for global daily coverage (early afternoon local time overpass), tropospheric column concentrations (Ω) of NO_2 and HCHO are sometimes below instrument detection limit or obscured by clouds. Given that we calculate monthly mean ΩNO_2 and ΩHCHO by averaging all daily concentrations at each grid cell during that month, we check here for consistency in the sample size of daily observations between months. Additionally, the fact that drier conditions often correspond with clearer skies necessitates a comparison of the number of daily data points factoring into ΩNO_2 and ΩHCHO monthly mean calculations for drought months in comparison with normal months (Figure S2). In order to eliminate monthly mean concentrations that would be calculated using a small sample size (very few daily measurements), and thus could be disproportionately biased by outlying values, we include only monthly mean concentrations that incorporate at least 10 daily measurements (Figure S2). The range of valid observations for ΩHCHO is -50 molecules cm^{-2} to 100 molecules cm^{-2} (Zhu et al., 2017). We include negative values in monthly mean calculations to avoid upward bias.

For the vast majority of the Eastern US, grid cells contain at least 10 daily ΩHCHO measurements during 80-100% of summer months from 2005-2015 (Figure S3b). Meanwhile, portions of the southeast, northeast, and Appalachian regions often contain fewer than 10 daily

ΩNO_2 measurements from 2005-2015 (Figure S3a), likely because ΩNO_2 values fall below the OMI/Aura instrument limit of detection.

Text S3

The SPI dataset is calculated by inputting precipitation population samples (in our case, monthly mean values) and comparing each value to a probability distribution that incorporates all population sample data from a given location and a given time period. For example, this means that precipitation data from a grid cell in southern New Hampshire for the month of June in a specific year is compared to precipitation data from the same grid cell in June for many consecutive years (in our case using CRUS TS data from the years 1901-2018). Either a gamma distribution algorithm converts precipitation values to a normal (Gaussian) distribution, or precipitation values are converted directly using a normal distribution to SPI values representing the following function (see accompanying repository for code):

$$SPI = \frac{P - \bar{P}}{\sigma_P},$$

where P represents a monthly mean precipitation value for a given calendar month and a given spatial grid cell, $\bar{P}$ represents a long term monthly mean precipitation value for the same given calendar month and spatial grid cell, and σ_P represents a normal standard distribution of precipitation (Keyantash & National Center for Atmospheric Research Staff, 2018).

The STI dataset is calculated using the same statistical approach as the SPI dataset, but using GHCN + CAMS temperature data as its input and always using a normal (Gaussian distribution) to convert temperature data to STI, with monthly temperature data available from 1948-2018 (Zscheischler et al., 2014).

Text S4

Before performing analyses that use Welch's T-test to compare $\Omega HCHO$ and ΩNO_2 during drought and normal months, we apply a counting function to SPEI, SPI, and STI grid cells to quantify the number of drought months (SPEI < -1.3) and normal months (-0.5 < SPEI < 0.5) during the temporal range of study in each spatial grid cell (Figure S4). For overall drought, we include in analyses only those grid cells that experience at least three drought months and at least three normal months across the period of study (Figure S4). For P-driven and T-driven drought, we include in analyses only those grid cells that experience at least one drought month and at least one normal month across the period of study. The number of drought months and normal months in a given spatial grid cell may be different for measurements of $\Omega HCHO$ and ΩNO_2 because we only count months with at least 10 daily measurements, which varies between the two gases based on instrument detection limits for each gas.

Text S5

We exclude results for the Northeast mixed forests (Figure S5) from the main body of the paper because of highly limited spatial representation in data decreasing our confidence in the indicative nature of our inferences. In this region, only 11% (for NO_2; not shown) and 24% (for HCHO; not shown) of grid cells are represented in our analyses after applying the minimum requirement for number of drought and normal months (Figure S4). Comparatively, 46% of grid cells are represented in Midwest cropland and grassland analyses for both NO_2 and HCHO, while 62% and 75% are represented in Southwest woody savannas, for NO_2 and HCHO respectively (not shown).